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Abstract

This paper examines several models of the state's impact on pricing under the special conditions characterizing the structural hyperinflation crises in transitional economies. Different aspects of money supply optimization, budget rationalization and credit policy are discussed. The proposed models may be used to make recommendations about subsidies, interest rates and loans. The results are illustrated by examples from the Ukrainian economy.

Contents

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*Mikhail V. Mikhalevich**
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1 Introduction

The characteristics of a transitional economy, such as the dominance of state-owned property, strong monopoly influences (mainly from the state), the absence of centralized control of industry and prohibitive technology costs result in the rather unusual behavior of prices. In an earlier paper [1], an attempt was made to explain this behavior using several models of pricing. This paper develops these models further in order to describe the impact of governmental economic policy on pricing in the transitional period.

Two essential aspects of government policy influence prices during the transition to a market economy. The first is the attempted and usually unsuccessful use of different kinds of price controls, including "freezing" prices and subsidies, payments, and even the non-market distribution of goods. Pricing policies inevitably become one of the ill-fated subjects in the transition. Market reforms, even in the ideal case, must be accompanied by radical changes in the function of prices, so they have dramatically changed. This causes serious problems associated with inflation. In transitional economies, the serious pre-market disproportions in resource use, the lack of market infrastructure, the dominance of "black market" forces and other problems have added to the negative consequences of inflation. Therefore, despite the criticism of theoretical economists, the direct governmental control of prices is considered by many policy makers as the best way to "reduce the price of reforms", to allay the social instability and to eliminate the destructive impact of inflation. Despite their limited scale, examples of such controls applied in some developed countries (EU agricultural subsidies, for example) are strong arguments for the policy of controlling prices.

Secondly, the governmental policy also has a significant impact on prices outside of direct price controls. Such measures as taxes, state investments, fiscal and budgetary policy have a strong indirect influence on prices. The budget deficit, outlays of money and credits, have been traditionally considered among the most important reasons for inflation [2]-[3]. This is particularly pronounced in the market transition given the high ratio of government expenditures to national income (0.65 - 0.7 in the Ukraine in 1993, for example [4]), given that these expenditures go mainly to industry and given chronic shortages of money in conditions of high inflation. The connection between inflation and money supply acquires specific features especially when prices are set mainly on the basis of costs.

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These two aspects of the state's influence on prices are closely connected. For example, subsidies to "control" prices together with credits to declining enterprises are the main reasons for a large budget deficit. Trying to reduce it, the state increases taxes. This leads to industrial decline, increased costs and ultimately to further inflation. As a result, instead of expected increases in the real budget, revenues decrease.

Therefore, an integrated systems study of all aspects of the state impact on prices is vitally necessary for the transitional period. Mathematical modeling can be the basis for such a study. Several models to this end are considered in this paper.

The modification of the dynamical macromodel from [1] is shown in Section 2. The purpose of this modification is to estimate the influence on prices of such factors as supply–demand disequilibrium, growth of costs in industry and money supply increases. This modification will allow us to estimate the consequences of outlays of money and credits.

An aggregated simulation model of the state budget is considered in Section 3. It can be used to analyze the consequences of tax policy and decisions about budget outlays. To provide an explanation of the impact of the budget deficit or surplus on the dynamics of prices and, consequently, on budget revenues is the main goal of this model.

A model of the stimulation of the production of monopolies through changes in interest rates and loans is developed in Section 4. Tentative conclusions are suggested and directions for further research are discussed in Section 5.

2 Money Supply and Price Dynamics in a Transitional Economy

Monopoly concentration and the limited character of market pricing in a transitional economy create a situation in which increases in the money supply may not only be the reason for but also the consequence of different types of inflation. Three types of inflation typical for a transitional period were considered in [1]. They are: a) price changes are a result of supply – demand disequilibrium; b) price increases are connected with the growth of costs as a result of intersector disproportions; c) price growth is a result of monopoly pricing. By limiting the amount of money in circulation, we can reduce the effects of the first and, partially, the third types of inflation. The reason that the second type is not affected is that its mechanism is determined by deep disproportions in the structures of technologies which are typical for high-cost, centralized economies. The elimination of these disproportions requires a long time and a great deal of material and financial expenditures. Therefore, some "noise" level of inflation is apparently present even under conditions of anti-inflation monetary policy. This level may even be increased as a result of shortages of investments for industrial reconstruction.

The estimation of the impact of conditions which lead to inflation and the determination of the size of the money supply which does not produce the extra (upper "noise" level) inflation are very important. For this purpose, the following modification of the dynamical macromodel [1] is proposed:

$$\begin{aligned} \frac{dx(t)}{dt} &= (1-a)\, b\, (W - W_o)\, x\,(t)\,, \\ R(t) &= (1-a)\tilde{W} x(t)\,, \\ \frac{dp_1(t)}{dt} &= m(S(t) - R(t))\,, \end{aligned}$$

$$\frac{dS(t)}{dt} = \frac{d}{dt}\left(\frac{D(t)}{p(t)}\right), \tag{1}$$

$$\frac{dD(t)}{dt} = qp(t)(1-a)x(t) - p(t)\min(S(t), R(t)),$$

where $x(t)$ is the value of the gross national product (GNP) of a closed economic system at the time t; a is the total expenditures per unit GNP, $R(t)$ is a consumed part of national income (NI); W is the portion of accumulation in the total NI. W_o is the minimal appropriate level of investment which can prevent the industrial decline; $S(t)$ is the value of consumer demand at time t; $p(t)$ is the price level at this time, $p_1(t)$ is its component to be determined by the supply – demand disequilibrium; $D(t)$ is the value of money stock of consumers; q is the ratio of consumer incomes to NI, and m is the Walras equation coefficient. $\tilde{W}$ is the portion of consumption in the total NI, and b is the rate of GNP growth/decline per unit investment.

The cost level $\hat{p}(t)$ also determines the value of p. We can begin by assuming that the scenario of inflation which we called in [1] the "structural hyperinflation crisis" takes place, in which case exponential growth of $\hat{p}(t)$ is typical. This can be expressed as:

$$\hat{p}(t) = \hat{p}(o)e^{\mu t}. \tag{2}$$

The third inflation factor proposed in the model is the impact of the money supply, which under conditions of hyperinflation is described by Cagan's equation [2]:

$$ln(M/p_2) = \alpha E(M,p) + \gamma, \tag{3}$$

where M is the amount of money in circulation, E is the expected inflation to be determined by the price level p and the amount of money M, α and γ are given constraints, p_2 is the price level to be determined by M and E ("the emissional price").

Let us assume that the price level p is determined at every time period t as the maximum of the "market" price p_1, the "cost" price $\hat{p}$ and the "emissional" price p_2:

$$p = \max(p_1, \hat{p}, p_2). \tag{4}$$

The equations (1) - (4) with the initial conditions for variables $x, p_1, S, D, \hat{p}$ valued at the period $t = 0$ comprise the model for further consideration.

The initial data collection for the model plays an essential role. The problems of m and μ identification, in particular, have been discussed in [1]. In the present paper, we discuss the identification of the parameters for equation (3).

The relevant time series data which characterizes the Ukrainian hyperinflation in 1993 is presented in Table 1. Large money supply increases in the second half of 1993 were, no doubt, the main inflation factor. For this reason, we have chosen the data mainly from this period.

Despite the limitation on the time series data, the accuracy of the approximation for equation (3) was between 20% and 30%. It should be noted that the best accuracy corresponds to the simpliest variant of equation (3), in which the expected inflation is assumed to be equal to the observed rate of price growth. The weak development of the market infrastructure and the absence of market experience force producers to adopt the principle, "expect what is observed", which makes this result quite predictable.

A comparison of the estimated values of α and γ with the actual values of α and γ for the period of hyperinflation in countries with a developed market economy for the period 1920 – 1950 has been carried out elsewhere [2], [6] – [8]. This comparison shows that the

Table 1: Money Supply Increases and Expectations During the Ukrainian Hyperinflation.

Month 1993	Amount of Money (M = M1), bln. crb.	Consumer Price Index (% to previous month)	Expected Yearly Inflation $E(M,p)$ (in %)
January	2,575	208.89	13,066
June	6,099	171.70	8,604
July	9,527	137.60	4,512
August	16,101	121.74	2,610
September	22,513	180.26	9,631
October	28,757	166.13	7,936
November	34,828	145.27	5,428

Initial data for the table were taken from [4].

impact of the expected inflation α was an order of magnitude less, and the value of γ parameter was about 20-40% greater for Ukrainian hyperinflation of 1993.

This may be our argument for the proposition that the inflation in the CIS countries is mainly borne by high industrial expenditures [1].

To forecast the consequences of the money supply increases let us estimate the impact of M value increases at some period of time, $t = t_o$, under the above assumption concerning expected inflation. Firstly, we assume M to be large enough to be the main cause of price increases, i.e., for some $t > t_o$, $p = p_2$ holds. Then equation (3) can be transformed into:

$$ln\frac{M}{p_2(t)} = \alpha\frac{dp_2(t)}{dt}/p_2(t) + \gamma, \; p_2(t_o) = p(t_o), \; t \geq t_o ,$$

or

$$\alpha\frac{dy(t)}{dt} - y(t) + \gamma = lnM ,$$

where $y = ln\ p_2$ and $y(t_o) = ln\ p(t_o)$.

The last equation has the solution

$$p_2(t) = exp((lnp(t_o) - lnM + \gamma)\, e^{-\alpha^{-1}(t-to)} + lnM - \gamma) , \tag{5}$$

for $t \geq t_0$. The function $p_2(t)$ is graphically presented in Figure 1.

Now let us estimate the value of M for which the given assumption holds, i.e., for which an interval $[t_0\,; t_1]$ exists such that

$$p_2\,(t) = \max\,(p_2\,(t),\, \hat{p}\,(t),\, p_2\,(t)) \tag{6}$$

holds for $t \epsilon\, [t_0\,; t_1]$.

This problem has an analytical solution for the case of $\hat{p}\,(t) > p_1\,(t)$ for $t \geq t_0$. This case is rather typical for the later stages of the structural hyperinflation crisis [1].

The following inequality derives from (2), (5), and (6).

$$\exp\,((ln\ p(t_o) - ln\ M + \gamma)\, e^{-\alpha^{-1}(t-to)} + ln\ M - \gamma) \geq p\,(t_0)\, e^{\mu(t-t_0)} .$$

This has an interval $[t_0\,; t_1]$ as its solution if

$$M \geq \bar{M} = \exp\,(ln\ p(t_0) + \alpha\mu + \gamma) . \tag{7}$$

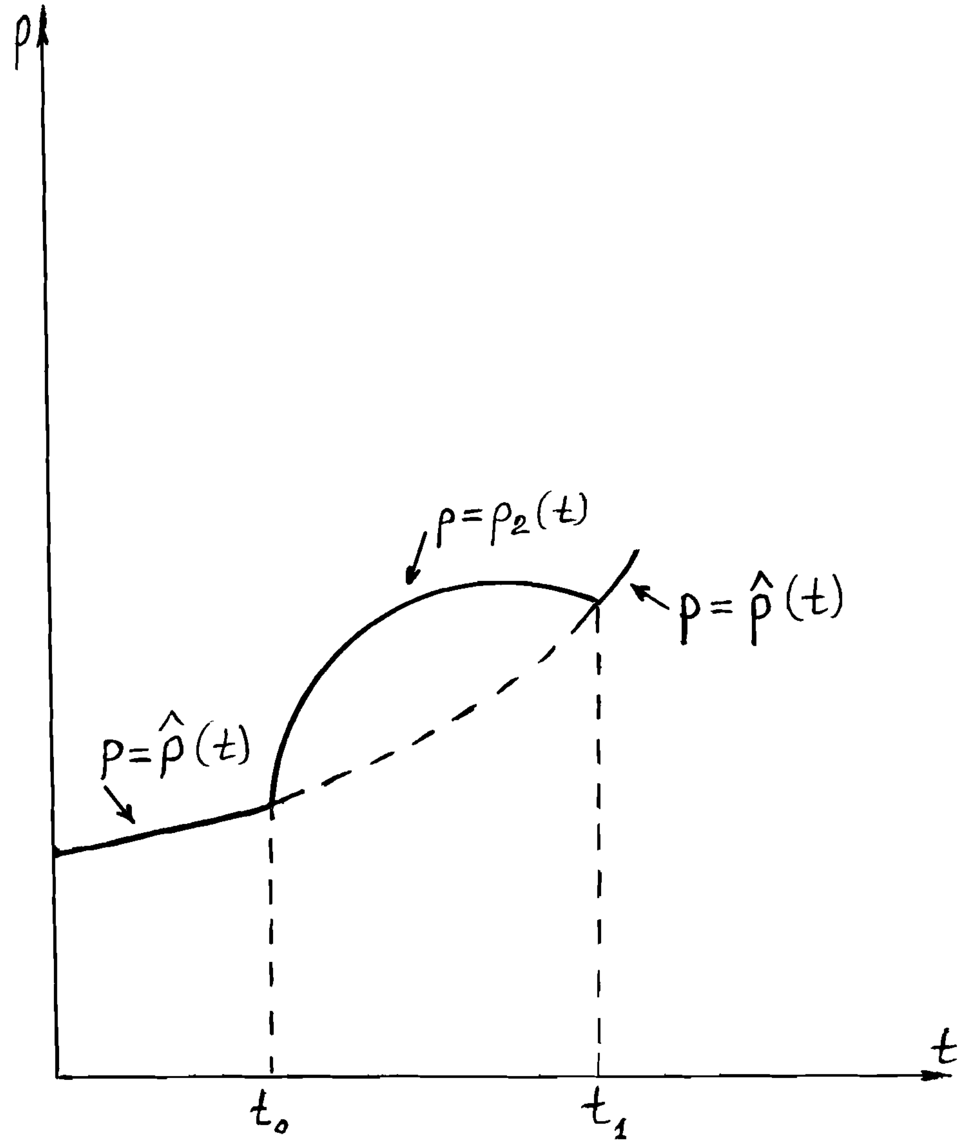

Figure 1: Emissional price.

Table 2: Modelling Results of Consequences of Structural Hyperinflation Crisis.

Date	Weighed Price Index (1991 = 1)	Consumers Money Stock (bln crb)	Overdemand(+) Oversupply (-) (% to total supply)	Optimum Amount of Money (10^{12} crb)	Real Amount of Money (10^{12} crb)
1 Jan 92	1.00	250.67	109.42	0.041	-(*)
Feb 92	5.92	434.705	-6.10^3	0.245	-
Apr 92	5.12	464.21	13.89	0.212	-
Jun 92	8.488	551.02	6.52	0.351	-
Aug 92	11.751	581.72	-2.65	0.486	-
Sep 92	16.71	630.82	-9.31	0.692	-
Nov 92	23.76	704.505	-13.13	0.984	-
1 Jan 93	33.79	805.91	-15.04	1.4	2.575
Feb 93	48.039	942.19	-18.3	1.99	3.01
Jun 93	279.224	2563.00	-24.76	11.57	6.099
Aug 93	397.03	3144.00	-25.36	14.45	16.101
Oct 93	564.543	3815.00	-25.9	23.4	29.665
Nov 93	802.73	4551.00	-26.4	33.27	34.82
1 Jan 94	1141.00	5290.00	-26.9	47.298	49.2
Mar 94	1452.00	6388.00	-26.67	60.17	-
May 94	1881.0	7995.0	-24.9	77.98	appr.73
Jul 94	2428.0	10184.0	-22.98	100.62	97
Oct 94	2633.0	11134.0	-21.53	109.131	-
Dec 94	2669.0	11383.0	-20.77	110.627	-

(*) Data not available.

In general, it is possible to solve the system (1), (2) by a numerical method and to calculate $p(t)$ as $p(t) = \max\ (p_1(t),\ \hat{p}(t))$, when $\hat{p}(t)$ is determined by (2). Further, the value of $p_2(t)$ is calculated by (5) for decreasing M until its minimal value $\bar{M}$, for which $p_2(t) \geq p(t)$ holds for some $[t_0\,;\,t_1]$ interval.

Let us give some conclusions. The additional (over $\bar{M}$) amount of money in circulation provides the additional (over its "noise" level $\max\ (p_1(t)\ ,\ \hat{p}(t))$ price growth at $[t_0\,;t_1]$ interval. If the amount of money is not greater than $\bar{M}$, no additional inflationary effects will be observed, and the price growth will be determined for reasons analyzed in [1].

Calculations of the Ukrainian economic data for 1992-93 were made on the basis of our model (equations (1) - (4)). The results are presented in Table 2, which also shows values of $\bar{M}$ calculated for selected periods of time. It should be noted that the cost increases in industry became the main factor of inflation after the autumn of 1992. As a result, the oversupply of goods and services in 1993 was about 20 bln roubles (in constant 1990 prices) or more than 25% of GNP. This provoked the payment crisis which has become more severe since the autumn of 1993.

Moreover, it should be noted that the 1993 money supply often exceeded $\bar{M}$. This produced the additional inflationary effects of about 40% of total price growth.

Additional outlays of money may be clarified by the attempts to alleviate the financial deterioration of industry created by the payment crisis. For example, money supply increases in the summer of 1993 mainly to provide state credits to the coal industry. Let us analyze the expediency of such a strategy.

The real money supply M/p being calculated with price changes account is estimated for the period $t = t_0 + \Delta t$, where t_0 is the moment of time for monetary emission. The price growth is independent of M, if $M \leq \bar{M}$, so M/p will increase when M increases. But $p(t) = p_2(t)$ holds if $M > \bar{M}, t > t_0$. As far as $p_2(t)$ is determined by (5), for a sufficiently large Δt

$$e^{-\alpha^{-1}\Delta t} \approx 0 \text{ and } \mathrm{p}_2(\mathrm{t} + \Delta \mathrm{t}) \approx \exp(\ln \mathrm{M} - \gamma) .$$

So $M/p(t) \approx e^{-\gamma} = \text{const}$ if $\mathrm{t} \geq \mathrm{t}_0 + \Delta\mathrm{t}$. The real money supply is nearly independent from its nominal value M in this case. The outlay of money which makes the value of M greater than $\bar{M}$ reduces the deficit of money only for a very short time $t \leq \Delta t \approx 10\alpha$; with respect to current Ukrainian data, this time interval lies between two and three months. Then price increases and the real money supply will return to their earlier level.

3 An Aggregated Simulation Model for the State Budget

The development of the rational budget is one of the vital issues of economic stabilization. This development possesses some special features in the transitional economy. The structure of expenditures is one of them. The financial stability of state enterprises cannot be assured without large subsidies if prices are rapidly changing. Therefore, such subsidies become the main budget expenditures (see Table 3). Their values are strongly determined by current prices for manufactured and consumer goods production. Another important goal of the subsidies is to control prices and to stimulate activity in the main industrial sectors. The budget also produces a fundamental and indirect influence on prices through money supply increases to cover the deficit, through taxes which can change the cost of production and through the budget payments which change consumer demand. Therefore, the problems of pricing and budget modelling are closely connected.

It should be noted that the reduction of the budget deficit is important not only for the period of planning as a whole, but also for every subperiod. For example, the budget deficit in the Ukraine in 1993 was about 15% of the expenditures. But for several months of this year, it was more than 50% of the total income (see Table 3). Of course, this destabilized the financial situation. Dynamic models for the budget analysis are necessary for accounting of such effects.

The well-balanced budget is necessary but not sufficient for financial stability in the economic transition. The dominance of state enterprises (each of which is managed independently but bears no responsibility for the results) and the absence of a working bankruptcy mechanism create possibilities for large out-of-budget outlays of money and credits, such as took place in the Ukraine in the late months of 1993.

The estimation of the productive impact of the budget is also important. High taxes accelerated the industrial decline and decreased the real budget incomes. This produced a higher budget deficit than had been planned.

In this Section, we develop a simulation model for the purpose of analyzing the proposed state budget taking into account the discussed peculiarities. This model is based on the following assumptions:

1. The economic system consists of N sectors (producers). M group of consumers, and the state budget is the subject of consideration.

Table 4: Expenditures of Ukrainian Budget in 1993.

Items	June		July		August		September		October		November	
of Expenditures	mln crb	% to expend.	mln crb	%	mln crb	%	mln crb	%	mln crb	%	mln crb	%
Industrial subsidies	941537	25.45	778707	24.46	537912	19.71	1824784	26.25	2415233	28.74	401787	4.13
Agricultural subsidies	799482	21.61	936531	29.40	144151	5.28	2084700	29.99	1282053	15.26	2408052	24.76
Social protection	627732	16.97	100573	3.15	631340	23.13	843683	12.13	1161054	13.82	2197125	22.59
Education	273873	7.4	302494	9.5	289135	10.59	620619	8.93	1085174	12.91	1148306	11.81
Health protect.	203564	5.5	295240	9.2	344214	12.61	556865	8.01	889469	10.58	1141798	11.74
State services	40042	1.08	58406	1.83	45969	1.68	112156	1.61	145991	1.74	199907	2.05
Defence	84630	2.28	233120	7.32	184875	6.77	249770	3.59	238894	2.84	414233	4.26
Foreign trade subsidies	351400	9.5	115060	3.61	261069	9.56	50800	0.73	195350	2.32	384474	3.95
Chernobyl disaster	132600	3.6	187619	5.89	89652	3.28	224780	3.23	142594	1.69	487766	5.01
Other expend.	245974	6.65	179581	5.64	201994	7.4	384463	5.53	840330	10.1	943422	9.7
Total expend.	698856	100	3184070	100	2729645	100	6952319	100	8403293	100	9726009	100
Total income	1586325	–	3059975	–	2993876	–	4764516	–	9167822	–	7652647	–
Budget deficit	2112531	57.11	124095	3.89	- 26423	- 9.6	2187803	31.47	- 764529	- 9.0	2073362	21.32

2. The main sources of budget revenues are the taxes on producers, the taxes on consumers' incomes, fixed payments from producers and consumers, and other payments.

3. The following taxes on producers are considered:

   a) a VAT being determined by the rate $q^{(1)}$, probably permitting the sectors' differentiation;

   b) taxes on profits with the rate $q^{(2)}$, which also assumes the sectors' differentiation;

   c) excise taxes on the production of some sectors, let $q^{(3)}$ be the part of the excise tax in the price.

4. Budget revenues from the above taxes are proportional to the current prices and the value of production of the sectors to be sold (the realization of production).

5. Taxes on consumers' incomes are determined by the rate $q^{(4)}$, which is different for different consumer groups, and are assumed to be calculated on the basis of nominal consumers incomes.

6. The values of fixed payments to the budget and other budget incomes are assumed to be known.

7. The main budget expenditures are subsidies for sectors of industry, payments for consumers (both indexed i.e., recalculated in connection with the current inflation rate, and nonindexed payments) and other expenditures. Subsidies are assumed to be proportional to the values of production in the different manufacturing sectors; recalculation of consumers payments is made according to the weighted price index which is calculated by values of the realization of production of sectors in current and constant (conditional) prices. Values of the other expenditures are assumed to be known.

8. The pricing mechanism discussed in the previous Section is used in this model.

9. Three kinds of prices for sectoral production are considered in the model:

   a) fixed prices, when the subsidies from budget cover the total difference between the constant price for the production and its cost (together with appropriate profits);

   b) controlled prices, when the state covers only the fixed part of this difference or pays producers the subsidies of the fixed value;

   c) free prices without the state subsidies.

   Let us denote the set of sectors with fixed prices as Ω_1, the set of sectors with controlled prices as Ω_2, and the set of sectors with free prices as Ω_3.

10. Model timing is made at the interval $[0;T]$ with fixed step value at Δt.

The initial model data are:
a_{ij} — the value of the direct sales in constant prices of the production of i-th sector to the manufacturing of the production of j-th sector ($i,j = \overline{1,N}$);

$\bar{q}_j$ — the proportion of total consumers incomes in the price for production of the j-th sector ($j = \overline{1,N}$);

$\hat{q}_j$ — the proportion of the j-th sector profits in the price for its production ($j = \overline{1,N}$);

q_j^+ — the proportion of other surplus components in the price for production of the j-th sector ($j = \overline{1,N}$);

$q_j^{(1)}$ — the VAT rate for the production of the j-th sector ($j = \overline{1,N}$);

$q_j^{(2)}$ — the rate of taxes to profit of the j-th sector ($j \epsilon\ \Omega_2\ U\ \Omega_3$), it is assumed that $q_j^{(2)} = 0$, if $j \epsilon\ \Omega_1$;

$q_j^{(3)}$ — the part of the excise tax in the price for the j-th sector production ($j \epsilon\ \Omega_2\ U\ \Omega_3$); it is assumed that $q_j^{(3)} = 0$ if $j\ \epsilon\ \Omega_1$;

$x_j(t)$ — the forecasted value of j-th sector production in constant (conditional) prices at the time $t\ \epsilon [0;T]$; in the other variant this is the upper bound of j-th sector production being determined by its capacities and resources ($j = \overline{1,N}$);

$B_j(t)$ — total expenditures per unit of the j-th sector production connected with external sales ($j = \overline{1,N}$);

$W_j(t)$ — expected additional (over $\hat{q}_j$ level) profit of the j-th sector at time moment $t(j\ \epsilon\ \Omega_2\ U\ \Omega_3\ , t\ \epsilon\ [0;T])$;

$\bar{W}_j(t)$ — subsidies per unit of the production of j-th sector at time t;

$H(t)$ — the value of budget incomes from fixed payments at time t;

$\hat{H}(t)$ — the value of budget incomes from other sources;

$\bar{p}_j(t)$ — the value of the fixed price for the production of j-th sector ($j\ \epsilon\ \Omega_1\ ,\ t\ \epsilon\ [0;T]$);

g_j — the part of the production to be consumed in the total production of the j-th sector ($j = \overline{1,N}$);

β_{jk} — the part of the production of the j-th sector in the menue of the consumer from k-th group ($j = \overline{1,N}\ ,\ k = \overline{1,M}$);

$Q_k^{(1)}$ — total indexed payments (in constant prices) from the budget to the consumers of the k-th group ($j = \overline{1,M}$);

$Q_k^{(2)}$ — total nonindexed payments for k-th consumer group ($k = \overline{1,M}$);

$G(t)$ — other budget expenditures at the time moment t ($t\ \epsilon\ [0;T]$) ;

C_{jk} — the part of k-th consumer group in total incomes obtained by all consumers from j-th sector ($j = \overline{1,N}\ ; k = \overline{1,M}$);

$D_k(0)$ — the money stock of the k-th consumer group at time $t = 0$;

$\bar{M}(t)$ — forecasted amount of money in circulation at the time t under the assumption of a zero budget deficit at the interval $[0;t]$;

α, γ — parameter of Cagan's equation (3).

The following variables determine the model state of every moment of time $t\ \epsilon\ [0;T]$:

$p_j(t)$ — relative (to constant) price for the production of j-th sector ($j\ \epsilon\ \Omega_2\ U\ \Omega_3$);

$\tilde{p}_j(t)$ — the cost and necessary profit of j-th sector production being calculated in relative prices;

$y_j(t)$ — production of the j-th sector which can be consumed;

$Z_j(t)$ — the value of realization of the production of the j-th sector;

$\pi_j(t)$ — profits of the j-th sector;

$\bar{\pi}_j(t)$ — total consumers' incomes obtained from the j-th sector;

$M(t)$ — amount of money in circulation under the assumption that the budget deficit is covered by the increase in the money supply;

$\hat{p}(t)$ — weighed price index;

$S_j^k(t)$ — the payable demand of the k-th consumer group for the production of the j-th sector;

$D_k(t)$ — the money stock of the k-th consumer group;
$A^o(t)$ — total budget incomes;
$B^o(t)$ — total budget expenditures.

Using the approach to cost estimation proposed in [9], the part of surplus $\tilde{q}_j$ at the price for the j-th sector production and the coefficients of multisectoral price impact $\bar{a}_{ij}$ are calculated by the formula:

$$\tilde{q}_j = \frac{\bar{q}_j + q_j^+}{1 - q_j^{(1)}} + \frac{\hat{q}_j}{(1 - q_j^{(1)})(1 - q_j^{(2)})} + q_j^{(3)}, \; j = \overline{1,N}$$

$$\bar{a}_{ij} = \begin{cases} \frac{a_{ij}}{1 - a_{jj} - \tilde{q}_j}, & \text{if } i \neq j \\ 0 & \text{otherwise.} \end{cases}$$

The total sales per capita $\hat{a}_{ij}$ are also obtained as elements of $(E - A)^{-1}$ matrix, where E is a unit matrix, $A = \{a_{ij}\}$.

The following operations are made for every time period $t = 0, \Delta t, 2\Delta t, ...T - \Delta t$:

1. The values of the relative prices are calculated as

$$\tilde{p}_j = \sum_{i \epsilon \Omega_1} a_{ij} \bar{p}_j(t) + \sum_{\substack{i \epsilon \Omega_2 U \Omega_3 \\ i \neq j}} \bar{a}_{ij} p_i(t) + B_j(t + \Delta t) +$$

$$+ \frac{1 - q_j^{(2)}(1 - q_j^{(1)})}{1 - q_j^{(1)}} W_j(t + \Delta t) - y_j(t + \Delta t), \; j \epsilon \Omega_2 U \Omega_3 \,,$$

where

$$y_j(t + \Delta t) = \begin{cases} \bar{W}_j(t + \Delta t), & \text{if } j \epsilon \Omega_2, \\ 0 & \text{if } j \epsilon \Omega_3 \,, \end{cases}$$

and

$$p_j(t+\Delta t) = \max\left(\tilde{p}_j(t+\Delta t), \exp\left((ln(p_j(t)) - ln(M(t)) + \gamma) e^{-\alpha^{-1}\Delta t} + ln(M(t)) - \gamma\right)\right).$$

The last equality is the analog of (4) - (5).

2. The values of subsidies necessary for establishing fixed prices are obtained:

$$\bar{W}_j(t + \Delta t) = \sum_{\substack{i \epsilon \Omega_1 \\ i \neq j}} \bar{a}_{ij} \bar{p}_i(t) + \sum_{i \epsilon \Omega_2 V \Omega_3} \bar{a}_{ij} p_i(t) + B_j(t + \Delta t) +$$

$$+ \frac{1 - q_j^{(2)}(1 - q_j^{(1)})}{1 - q_j^{(1)}} W_j(t + \Delta t) - \bar{p}_j(t + \Delta t) \,, j \epsilon \Omega_1 \,.$$

3. The values of production of sectors to be proposed for consumption are calculated:

$$y_i(t + \Delta t) = (x_i(t + \Delta t) - \sum_{j=1}^{N} a_{ij} x_j(t + \Delta t)) g_i \,, i = \overline{1,N} \,,$$

the demand of every consumers' group for the j-th production will be

$$S_j^k(t + \Delta t) = \frac{D_k(t) \beta_{jk}}{p_j(t + \Delta t)} \,.$$

4. The values of production for the j-th sector are obtained as

$$Z_j(t+\Delta t) = \sum_{j=1}^{N} \hat{a}_{ij} \left(\min \sum_{k=1}^{M} S_j^k(t+\Delta t)\,,\, y_j(t+\Delta t)\right) + \tilde{Z}_j(t+\Delta t))\,,$$

where $\tilde{Z}_j$ is the production of the j-th sector to be used for non-productive and non-consumptive activity.

5. The weighted price index is calculated as:

$$\hat{p}(t+\Delta t) = \frac{\sum_{j=1}^{N} p_j(t+\Delta t)Z_j(t+\Delta t)}{\sum_{j=1}^{N} Z_j(t+\Delta t)}\,,$$

where $p_j = \bar{p}_j$, if $j \epsilon\, \Omega_1$.

6. The profits of sectors and consumers incomes are calculated as:

$$\pi_j(t+\Delta t) = p_j(t+\Delta t)Z_j(t+\Delta t) - \left(\sum_{i\epsilon\Omega_1} \bar{a}_{ij}\bar{p}_i(t) + \sum_{\substack{i\epsilon\Omega_2 U\Omega_3 \\ i\neq j}} \bar{a}_{ij}p_i(t) + \right.$$

$$\left. + B_j(t+\Delta t) + \frac{1-q_j^{(2)}(1-q_j^{(1)})}{1-q_j^{(1)}} W_j(t+\Delta t) - y_j(t+\Delta t) \right) x_j(t+\Delta t)\,, j\epsilon\Omega_2 U\Omega_3\,,$$

$$\pi_j(t+\Delta t) = \hat{q}_j Z_j(t+\Delta t)\bar{p}_j(t+\Delta t)\,, j\epsilon\Omega_1\,,$$

$$\bar{\pi}_j(t+\Delta t) = \begin{cases} \bar{p}_j(t+\Delta t)\bar{q}_j Z_j(t+\Delta t), & j\epsilon\Omega_1\,, \\ p_j(t+\Delta t)\bar{q}_j Z_j(t+\Delta t), & j\epsilon\Omega_2 U\Omega_3\,. \end{cases}$$

7. Consumer money stocks are calculated as:

$$D_k(t+\Delta t) = D_k(t) + \sum_{j=1}^{N} C_{jk}\bar{\pi}_j(t+\Delta t) + \hat{p}(t+\Delta t)Q_k^{(1)}(t+\Delta t) +$$

$$+ Q_k^{(2)}(t+\Delta t) - \sum_{j=1}^{N} p_j(t+\Delta t) \min \left(S_j^k(t+\Delta t), \frac{\beta_{jk} S_j^k(t+\Delta t)}{\sum_{l=1}^{M} S_j^i(t+\Delta t)} \right)\,,$$

where $p_j = \bar{p}_j$, if $j \epsilon\, \Omega_1$.

8. The values of budget incomes are determined:

   a) from VAT as

$$h^{(1)}(t+\Delta t) = \sum_{j=1}^{N} q_j^{(1)}\, \tilde{q}_j p_j(t+\Delta t)Z_j(t+\Delta t)\,,$$

   where $p_j = \bar{p}_j$ is assumed if $j\epsilon\Omega_1$;

b) from taxes to profits of sectors as:

$$h^{(2)}(t+\Delta t) \; = \; \sum_{j=1}^{N} q_j^{(2)} \pi_j(t+\Delta t) \; ;$$

c) from excise taxes:

$$h^{(3)}(t+\Delta t) \; = \; \sum_{j=1}^{N} q_j^{(3)} p_j(t+\Delta t) Z_j(t+\Delta t) \; ;$$

d) from taxes to consumers' incomes:

$$h^{(4)}(t+\Delta t) \; = \; \sum_{k=1}^{M} q_k^{(4)} \left(\sum_{j=1}^{N} C_{jk} \bar{\pi}_j(t+\Delta t) \; + \; \hat{p}(t+\Delta t) Q_k^{(1)}(t+\Delta t) \; + \right.$$

$$\left. + \; Q_k^{(2)}(t+\Delta t) \right) \; .$$

9. The total budget income is calculated as

$$B^0(t+\Delta t) \; = \; \sum_{l=1}^{4} h^{(l)}(t+\Delta t) \; + \; H(t+\Delta t) \; + \; \hat{H}(t+\Delta t) \; .$$

10. Expenditures for sectors subsidies are

$$\bar{W}(t+\Delta t) \; = \; \sum_{j \epsilon \Omega_1 U \Omega_2} \bar{W}_j(t+\Delta t) x_j(t+\Delta t) \; .$$

11. The total expenditures of budget are calculated as

$$A^o(t+\Delta t) \; = \; \bar{W}(t+\Delta t) \; + \; \sum_{k=1}^{M} \left(\hat{p}(t+\Delta t) Q_k^{(1)}(t+\Delta t) \; + \; Q_k^{(2)}(t+\Delta t) \right) \; +$$

$$+ \; G(t+\Delta t) \; .$$

12. The new value of the total amount of money in circulation is obtained:

$$M(t+\Delta t) \; = \; M(t) \; + \; (\bar{M}(t+\Delta t) \; - \; \bar{M}(t)) \; + \; (A^o(t+\Delta t) \; - \; B^o(t+\Delta t)) \; .$$

At time $t = 0$ the values of the variables are calculated by the following rule. Values of $D_k(0), p_j(0), k = \overline{1,M}\;,\; j = \overline{1,N}$ are assumed to be known. Values of $y_i(0)\;, i = \overline{1,N}, S_j^k(0), k = \overline{1,M}, j = \overline{1,N}$ are calculated by the formula:

$$y_i(0) = (x_i(0) - \sum_{j=1}^{N} a_{ij} x_j(0)) g_i \;,\; i = \overline{1,N} \;;$$

$$S_j^k(0) = \frac{D_k(0)\beta_{jk}}{P_j(0)} \;, k = \overline{1,M} \;, j = \overline{1,N} \; .$$

The value of $\pi_j(0)$ is obtained as

$$\pi_j(0) = p_j(0) Z_j(0) \; - \; \left(\sum_{l=1}^{N} a_{ij} p_i(0) \; + \; B_j(0) \; + \right.$$

$$+ \frac{1 - q_j^{(2)}\,(1 - q_j^{(1)})}{1 - q_j^{(1)}}\, W_j(0) \;-\; y_j(0)\Bigg)\, x_j(0)\,.$$

The values of other variables are calculated by the above formula, where $t + \Delta t$ is assumed to be equal to zero.

Modelling on the basis of multisectoral balances and other economic data [4] was made by this model. It shows the low efficiency of the "frozen" price policy for high cost sectors, which initiate the structural hyperinflation crisis [1].

The inflation impact of large money outlays, which are necessary to provide subsidies for such sectors, is no less in this case than the consequences of cost increases in such sectors. But the policy of "low taxes, no subsidies" leads to high rates of growth in total costs in all sectors under structural hyperinflation. This is inappropriate for the transitional economies with heavy industry dominance. The best policy is to subsidize the sectors which are weakly connected with industries which provoke the cost growth.

It should be noted that the assumption about the monopoly character of every producer is the basis of the discussed model. It must be modified to describe the decentralized economy, where producers of similar goods have different costs. But the structure of the new model will be the same as for the previous one.

4 Monopoly and Credit Policies

A high level of monopoly is one of the reasons for inflation in a transitional economy. In the conditions of unsaturated markets, a monopolist can obtain additional profits by reducing production, which leads to price increases.

It was shown in [1] that one possible way to stop such an activity is to increase the interest rate and, connected with it, loans. The resulting loss in profits cannot be compensated by additional future profits if the interest rate is higher than the inflation rate. Otherwise, the high interest rate generates a large amount of money in circulation, makes market unsaturation deeper and gives the monopolist an additional motivation to increase prices. Such a situation also stimulates savings, but does not direct them to manufacturing. Therefore, the optimum value of the interest rate exists, and this corresponds to the most productive activity of a monopolist. Let us consider the model to obtain this value.

Let us assume the producer exists who makes only one kind of good and this producer is a monopolist in his sector. His or her goal is to maximize profits in the time period $[0;T]$ with discounting. Being a monopolist, he or she can control prices by varying the value of this production, i.e., varying the supply-demand disequilibrium. The latter implies that prices change according to the equation of Walras [5].

Let us denote the price for the good at time t as $p(t)$, the portion of the price that is the producers' profit as $\hat{q}$, the value of the good to be produced at time t as $u(t)$, producers capacity as $\bar{u}$, the demand for the good as $S(t)$, the initial price at $t = 0$ as p_o, the coefficient of the pricing equation as m, the discounting coefficient being further interpreted as the interest rate as ν. For the given assumptions, the producer's activity can be described by the problem of optimal control:

$$\begin{gathered} \int_0^T e^{-\nu t} p(t)\hat{q}\ \min(S(t), U(t))dt \to \max \\ \frac{dp(t)}{dt} = m\,(S(t) - U(t)) \\ 0 \le U(t) \le \bar{u}\ ,\ t\epsilon\,[0,T]\, p(0) = p_o\ . \end{gathered} \tag{8}$$

Let us denote the optimum solution of this problem for given y, s as $(p^*\ ,\ u^*)$. Now let us consider the model of the stimulation of a production activity of a monopolist by the state which establishes the value of y parameter.

The minimization of the supply-demand disequilibrium is the state goal. Considered demand to be the ratio of consumers' money stock D to the price p. Two sources of consumers' income are assumed to exist: 1) income which consumers receive independently of producer profits (payments from the budget, for instance); 2) a fixed portion q of profits of the producer-monopolist. Let us also assume that the consumers' money stock is discounted with the same coefficient ν. If the intensity of the consumers' income is denoted as $Q(t)$, the following problem is obtained:

$$\int_0^T \max\,(S(t) - u*(t), 0)\; dt \to \min$$

$$\begin{aligned} \frac{dD(t)}{dt} &= \nu D(t) + (1+\nu)(Q(t) + \hat{q}qp^*(t)\,\min(S(t), U^*(t)) - \\ &\qquad - p^*(t)\,\min\,(S(t), u^*(t))\,, \\ \frac{dS(t)}{dt} &= \frac{d}{dt}(D(t)/p(t))\,, \\ D(0) &= D_o\,,\quad S(0) = S_o\,, \end{aligned} \tag{9}$$

where D_0, S_0 are the given values of D and S variables for $t = 0$.

The problems (8) - (9) are a rather complicated two-level problem of optimum control. But its simplification is possible.

Let's show that $u^*(t) \le S(t)$ for every $t\epsilon[0;T]$. Indeed, the producer has no reason to produce goods which cannot be sold, never bring him any profits and decrease prices which he tries to increase. Therefore, the equations of (9) can be substituted by linear ones:

$$\frac{dD(t)}{dt} = \nu D(t) + (1+\nu)(Q(t) + (\hat{q}q - 1)p^*(t)u^*(t))\,,$$

$$\frac{dS(t)}{dt} = \frac{d}{dt}\left(\frac{D(t)}{p^*(t)}\right)\,.$$

By substituting their solution $S(\nu, p^*, u^*)$ which is obtained for given ν in problem (8), we transform the latter to the former which allows the application of algorithm [1] for its solution. If we further substitute the solution of the latter to the objective function of (9), we obtain a rather complex, but quite solvable, one-dimensional optimization problem. Its solution ν^* will be the optimum value of the interest rate ν.

5 Conclusions

1. In order to develop an anti-inflation policy for a transitional economy, it is important to distinguish inflation that results from or does not result from monetary circulation. Anti-inflationary monetary measures are restricted by the special characteristics determining prices in a transitional economy. Monetary policy must be combined with policies of far-reaching structural changes in the economy, for instance, by government technological programs.

2. The optimum value of the amount of money in circulation has been calculated for every time period in a transitional economy. If the amount of money is less than the optimum, the deficit of money is increased and the economic decline is worsened.

3. If the amount of money is larger than the optimum, the deficit of money can only be reduced for a restricted time interval. Then the real amount of money, recalculated according to the changed prices, will be not greater than the optimum.

4. A rational development of the state expenditures together with optimum money supply increases are the most effective ways of the governmental intervention to effect pricing in a transitional economy. It is important not only to strive for a zero budget deficit, but also to optimize the influence of taxes on prices and the value of production.

5. Subsidies for some industrial sectors are necessary during the transition, but their negative and positive impact must be analyzed together with their connection with budget dynamics. The development of simulation models of the budget allows us to check how the budget will be fulfilled.

6. A high degree of industrial monopolism is typical for the transitional economy. Its negative impact may be reduced by a rational credit policy, in particular by optimization of interest rates.

The following studies will be made for further investigations:

a) the unification of the models, software and database for a transitional economy analysis and the creation of the modelling complex and intellectual decision-support system;

b) an analysis of the state impact on the value of produced goods and modelling of the interaction between goal programs and market structures in a transitional economy.

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